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In re application of: Lin et al.
Application No.: 09/201,278
Filed: November 30, 1998
For: EFFICIENT MOTION VECTOR CODING FOR VIDEO COMPRESSION
Examiner: Vu Le
Art Unit: 2613
Date: April 25, 2003

CERTIFICATE OF FACSIMILE

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Attorney for Applicant

☒ Reply Brief.

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April 25, 2003
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

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Attorney for Applicant

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REPLY BRIEF

This Reply Brief is in response to the Examiner's Answer mailed February 25, 2003.

CONTENTS

I. REPLY TO EXAMINER'S ANSWER TO ARGUMENT

The pending claims are allowable and should be passed to issue. The Examiner believes the rejections of the pending claims should be sustained. [*See* Examiner's Answer ("Answer") at p. 7.] Appellants respectfully disagree. The Examiner has not carried the burden of showing the cited art teaches or suggests each and every element of the claims. In particular, the Examiner has not shown that Yu et al., "Two-Dimensional Motion Vector Coding for Low Bitrate Videophone Applications," *Proc. Int'l Conf. on Image Processing*, p. 414-17 (1995) ("Yu") teaches or suggests the cited language of the claims.

A. The Rejections of Claims 1, 3-4, 7-9, 11-13, and 15-22 Under 35 U.S.C. § 102(b) as Being Anticipated by Yu Should Be Reversed.

Claims 1, 3-4, 7-9, 11-13, and 15-22 stand rejected under 35 U.S.C. § 102(b) as being anticipated by Yu. Yu fails to teach or suggest at least one element of each one of these claims. Accordingly, the rejections of claims 1, 3-4, 7-9, 11-13, and 15-22 should be reversed.

1. Claim 1

Claim 1 recites:

> wherein the table includes the most probable pairs of joint differential motion vector components as computed by statistical analysis of example video sequences.

Appellants submit that the Examiner has not met the burden of establishing that claim 1 is anticipated by Yu. Specifically, Yu does not teach or suggest the above-cited language of claim 1.

Yu does not use statistical analysis to determine which joint differential motion vector ("DMV") component pairs to include in its variable-length coding table ("VLC table"). The Examiner contends:

> In Yu (p. 415, 2nd column, ¶2, cases 1, 2 & 3), the 290 codes in the VLC table represent the "possible" absolute DMV values i.e., DMVx and DMVy, which are determined through training runs. In the example, the size of the VLC table depends on a finite number of training runs. The "possible" DMV values represent the "most probable" pairs of DMV components as claimed." Histogram analysis as discussed in Yu is the statistical analysis as claimed.

[*See* Answer at p. 4 (emphasis in original).] Appellants respectfully disagree.

Yu's VLC table represents the absolute values of DMV pairs in Region A. Other DMV pairs are possible (e.g., DMV pairs in Region B or Region C). The Examiner implies that the boundary separating Region A from Region B is determined through training runs in Yu. It is not. This would entail performing training runs for all of the DMV pairs in Regions A, B, and C, then setting the boundary between Region A and Region B in response. Yu does not describe such a procedure. Instead, Yu describes using the training runs only to determine lengths of variable-length codes ("VLCs") for the DMV pairs of Region A in the VLC table.

Yu chooses DMV pairs for its VLC table simply by postulating that, for most video sequences, the frequency of occurrence for small DMVs is high. At page 415, second column, Yu observes:

> The x or y component of the DMV in Region A ranges from -8.0 to 8.0 pixels. Most DMVs falls [sic] into this region because the frequency of occurrence for small DMVs is very high. A VLC table that consists of codes for 2-dim entries is first generated. The table contains 290 codes which represent the possible absolute DMV values from 0 to 8.0 in 0.5-pel division, and an escape code to be used to encode the DMV in Region B . . . .

Yu's supposition that smaller DMVs are more common in video sequences than larger DMVs leads directly away from including the most probable pairs of joint differential motion vector components as computed by statistical analysis of example video sequences.

Yu describes training, but the training is used only to determine the length of VLCs in the VLC table. The Examiner states:

> Yu (p. 16, 2nd column, [Simulation Results]) discloses that the 290 VLC codes are resulted from the training set of five test sequences. Later, Yu discloses (p. 417, middle of 1st column) that "the VLC code table is obtained based on a finite number of video sequences" i.e., based on the training set of five test sequences.

[*See* Answer at p. 4.] Looking at the context of the phrase, it is clear that "obtaining" the VLC table means determining the *length* of the VLCs, which is the sole purpose of training in Yu:

> The resulting codeword lengths range from 2 to 13 bits, including an escape code to be used to encode DMVs in Region B. The length for the escape code is 13. Theoretically speaking, the larger the absolute value of the DMV is, the smaller the frequency of occurrence it has, and therefore the longer its code length should be. However, since the VLC code table is obtained based on a finite number (5 in our simulation) of video sequences, the actual histogram slightly deviates from the theoretical histogram. Figure 3 illustrates the difference between actual and theoretical DMV histograms. It is found occasionally that a shorter code may correspond to a larger absolute value of DMV. This is because of the slight irregularity in the actual histogram from a finite training set of video sequences.

[*See* Yu at p. 417, first column.] Yu does not discuss determining which DMV pairs will be included in the VLC table (or, setting the boundary between Region A and Region B) anywhere in this context. If anything, the cited passage indicates that the boundary between Region A and B is determined before training.

Yu determines which DMV pairs will be included in the VLC table by making a guess about the frequency of occurrence of small motion vectors in video sequences. This determination is not based on training or statistical analysis. Although Yu may determine lengths of VLCs based on a training set, Yu does not use statistical analysis to determine which DMV pairs to include in the VLC table. Yu does not teach or suggest "wherein the table includes the most probable pairs of joint differential motion vector components as computed by statistical analysis of example video sequences," as recited in claim 1.

Accordingly, the rejections of claims 1 and 3-6 should be reversed.

2. Claim 7

Claim 7 recites:

> wherein training determines which x and y components to include in the entropy codebook.

Appellants submit that the Examiner has not met the burden of establishing that claim 7 is anticipated by Yu. Specifically, Yu does not teach or suggest the above-cited language of claim 7.

The Examiner contends:

> In Yu (p. 415, 2nd column, ¶2, cases 1, 2 & 3), again, the 290 codes in the VLC table represent the "possible" absolute DMV pairs, wherein each pair consists of DMVx and DMVy. As noted above, these DMV pairs <u>are determined</u> through training runs. Thus, DMVx and DMVy are the x and y components as claimed, and they represent a pair of DMV components which are included in the VLC table i.e. entropy codebook.

[*See* Answer at p. 4 (emphasis in original).] Appellants respectfully disagree.

Yu does not use training to determine which x and y components to include in the entropy codebook. As explained above, Yu determines which DMV pairs will be included in the VLC table by making a guess about the frequency of occurrence of small motion vectors in video sequences. Yu uses training only to determine lengths of VLCs for its VLC table. Yu does not teach or suggest "wherein training determines which x and y components to include in the entropy codebook," as recited in claim 7.

Accordingly, the rejections of claims 7 and 8-10 should be reversed.

3. Claim 11

Claim 11 recites:

> wherein statistical analysis indicates which differential motion vector components to represent with variable length codes and which differential motion vector components to represent with an escape code followed by fixed length codes.

Appellants submit that the Examiner has not met the burden of establishing that claim 11 is anticipated by Yu. Specifically, Yu does not teach or suggest the above-cited language of claim 11.

The Examiner contends, "Yu clearly discloses this aspect (p. 415, 2nd column, ¶2, cases 1, 2 & 3)." [*See* Answer at p. 5.] Appellants respectfully disagree.

Yu decides *without statistical analysis* which DMV pairs to represent with VLCs in its VLC table and which DMV pairs to represent with escape codes. As explained above, Yu determines which DMV pairs will be included in the VLC table by making a guess about the frequency of occurrence of small motion vectors in video sequences. Yu uses training only to determine lengths of VLCs for its VLC table. Yu does not teach or suggest "wherein statistical analysis indicates which differential motion vector components to represent with variable length codes and which differential motion vector components to represent with an escape code followed by fixed length codes," as recited in claim 11.

Accordingly, the rejections of claims 11 and 12 should be reversed.

4. Claim 13

Claim 13 recites:

> wherein training determines which joint differential motion vector components to include in the table and which joint differential motion vector components to exclude from the table.

Appellants submit that the Examiner has not met the burden of establishing that claim 13 is anticipated by Yu. Specifically, Yu does not teach or suggest the above-cited language of claim 13.

The Examiner contends:

> Yu discloses this aspect (p. 415, 2nd column, ¶2, cases 1, 2 & 3). It is emphasized that the determination of which DMV components fall within which regions (i.e., region A, B or C) effectively necessitates including/excluding DMV motion vector components from the VLC table.

[*See* Answer at p. 5.] Appellants respectfully disagree.

Even if, assuming for the sake of argument, determining which DMV components fall within which regions necessitates including/excluding DMV components from the VLC table (as the Examiner argues), Yu makes such a determination before performing any training. As explained above, Yu determines which DMV pairs will be included in its VLC table by making a guess about the frequency of occurrence of small motion vectors in video sequences. Yu uses training only to determine lengths of VLCs for its VLC table. Yu does not teach or suggest, "wherein training determines which joint differential motion vector components to include in the table and which joint differential motion vector components to exclude from the table," as recited in claim 13. Accordingly, the rejections of claims 13 and 15 should be reversed.

5. Claim 16

Claim 16 recites:

> wherein training determines which joint x and y motion vector components to represent in the set of available variable length codes.

Appellants submit that the Examiner has not met the burden of establishing that claim 16 is anticipated by Yu. Specifically, Yu does not teach or suggest the above-cited language of claim 16.

The Examiner contends:

> In Yu (p. 415, 2nd column, ¶2, cases 1, 2 & 3, p. 417, also 1st column), the number of training runs determine the number of codes in the VLC table that represent the DMV pairs, wherein each pair consists of DMVx and DMVy. The DMVx and DMVy are the x and y components as claimed, and they represent a pair of DMV components which are included in the VLC table.

[*See* Answer at p. 5.] Appellants respectfully disagree.

It is not the case that the "number of training runs determine the number of codes in the VLC table" in Yu, as the Examiner argues. As explained above, Yu determines which DMV pairs will be

included in its VLC table by making a guess about the frequency of occurrence of small motion vectors in video sequences. Yu uses training only to determine lengths of VLCs for its VLC table. Yu does not teach or suggest, "wherein training determines which joint x and y motion vector components to represent in the set of available variable length codes," as recited in claim 16.

Accordingly, the rejections of claims 16 and 17-18 should be reversed.

6. Claim 19

Claim 19 recites:

> wherein the Huffman table includes variable length codes for the most probable joint differential x and y components as computed by statistical analysis of example video sequences.

Appellants submit that the Examiner has not met the burden of establishing that claim 19 is anticipated by Yu. Specifically, Yu does not teach or suggest the above-cited language of claim 19.

The Examiner contends:

> In Yu (p. 415, 2nd column, ¶2, cases 1, 2 & 3), the 290 codes in the VLC table represent the "possible" absolute DMV values i.e., DMVx and DMVy, which are determined through training runs. In the example, the size of the VLC table depends on a finite number of training runs. The "possible" DMV values represent the "most probable" pairs of DMV components as claimed." Histogram analysis as discussed in Yu is the statistical analysis claimed. In Yu, the VLC table is also referred to as the Huffman table.

[*See* Answer at p. 6 (emphasis in original).] Appellants respectfully disagree.

As explained above, Yu determines which DMV pairs will be included in its VLC table by making a guess about the frequency of occurrence of small motion vectors in video sequences. Yu uses training only to determine lengths of VLCs for its VLC table. Yu does not teach or suggest, "wherein the Huffman table includes variable length codes for the most probable joint differential x and y components as computed by statistical analysis of example video sequences," as recited in claim 19.

Accordingly, the rejection of claim 19 should be reversed.

7. Claim 20

Claim 20 recites:

> wherein training determines which joint x and y motion vector components to represent in the set of available variable length codes.

Appellants submit that the Examiner has not met the burden of establishing that claim 20 is anticipated by Yu. Specifically, Yu does not teach or suggest the above-cited language of claim 20.

The Examiner contends:

> In Yu (p. 415, 2nd column, ¶2, cases 1, 2 & 3, p. 417, also 1st column), the number of training runs determine the number of codes in the VLC table that represent the DMV pairs, wherein each pair consists of DMVx and DMVy. The DMVx and DMVy are the x and y components as claimed, and they represent a pair of DMV components which are included in the VLC table.

[*See* Answer at p. 6.] Appellants respectfully disagree.

It is not the case that "the number of training runs determine the number of codes in the VLC table" in Yu, as the Examiner argues. As explained above, Yu determines which DMV pairs will be included in its VLC table by making a guess about the frequency of occurrence of small motion vectors in video sequences. Yu uses training only to determine lengths of VLCs for its VLC table. Yu does not teach or suggest, "wherein training determines which joint x and y motion vector components to represent in the set of available variable length codes," as recited in claim 20.

Accordingly, the rejections of claims 20 and 21 should be reversed.

8. Claim 22

Claim 22 recites:

wherein the Huffman table includes variable length codes for the most probable joint differential x and y components as computed by statistical analysis of example video sequences.

Appellants submit that the Examiner has not met the burden of establishing that claim 22 is anticipated by Yu. Specifically, Yu does not teach or suggest the above-cited language of claim 22.

The Examiner contends:

> In Yu (p. 415, 2nd column, ¶2, cases 1, 2 & 3), the 290 codes in the VLC table represent the "possible" absolute DMV values i.e., DMVx and DMVy, which are determined through training runs. In the example, the size of the VLC table depends on a finite number of training runs. The "possible" DMV values represent the "most probable" pairs of DMV components as claimed." Histogram analysis as discussed in Yu is the statistical analysis claimed. In Yu, the VLC table is also referred to as the Huffman table.

[*See* Answer at p. 7 (emphasis in original).] Appellants respectfully disagree.

It is not the case that "the size of the VLC table depends on a finite number of training runs" in Yu, as the Examiner argues. As explained above, Yu determines which DMV pairs will be included in its VLC table by making a guess about the frequency of occurrence of small motion vectors in video sequences. Yu uses training only to determine lengths of VLCs for its VLC table. Yu does not teach or suggest, "the table includes the most probable pairs of joint differential motion vector components as computed by statistical analysis of example video sequences," as recited in claim 22.

Accordingly, the rejection of claim 22 should be reversed.

B. The Rejections of Claims 5-6 and 10 Under 35 U.S.C. § 103 as Being Obvious in View of Yu Should Be Reversed.

Claims 5-6 and 10 stand rejected under 35 U.S.C. § 103 as being obvious in view of Yu. Yu fails to teach or suggest at least one element of each one of these claims. Moreover, nothing in Yu

would lead one of ordinary skill in the art to modify the system described in Yu to achieve the claimed limitations. Accordingly, the rejections of claims 5-6 and 10 should be reversed.

1. Claims 5-6

Claims 5 and 6 depend from claim 1 and incorporate the language of claim 1.

Appellants submit that the Examiner has not met the burden of establishing that claims 5 and 6 are obvious in view of Yu. Specifically, Yu does not teach or suggest the above-cited language of claim 1. Therefore, Yu does not teach or suggest at least one element of each of claims 5 and 6. Moreover, nothing in Yu would lead one of ordinary skill in the art to modify the system described in Yu to achieve each of the limitations of claims 5 and 6. Accordingly, the rejections of claims 5 and 6 should be reversed.

2. Claim 10

Claim 10 depends from claim 7 and incorporates the language of claim 7.

Appellants submit that the Examiner has not met the burden of establishing that claim 10 is obvious in view of Yu. Specifically, Yu does not teach or suggest the above-cited language of claim 7. Therefore, Yu does not teach or suggest at least one element of claim 10. Moreover, nothing in Yu would lead one of ordinary skill in the art to modify the system described in Yu to achieve each of the limitations of claim 10.

Accordingly, the rejection of claim 10 should be reversed.

C. <u>Appellants' Explanation of the Yu Reference</u>

With regard to part VIII.A of Appellants' Appeal Brief ("Appeal Brief"), the Examiner states:

> Appellants' arguments do not pertains to any issues relating to the claimed subject matter, but rather a summary of the Yu et al article. The comments are noted, however no rebuttal is necessary.

Appellants respectfully point out that Appellants' statements do pertain to issues relating to the claimed subject matter because the statements help establish that Yu does not teach or suggest the claimed subject matter.

Appellants therefore reiterate the following points concerning Yu:

- Yu's VLC table assumes, before training, that each and every pair of DMV x and y components in Region A is more likely to occur than any DMV pair in Regions B or C.
- The number and identity of the DMV pairs to be represented by VLCs in Yu's VLC table are not determined by training or statistical analysis.
- Yu describes, for *the pre-determined set of DMV pairs in Region A*, calculating VLCs based upon frequencies of occurrence in a training set of test sequences.
- Yu uses training to determine the relative lengths of the VLCs in the VLC table, not to select the DMV pairs to be represented by VLCs in the VLC table.

II. CONCLUSION

The final rejection failed to establish anticipation of claims 1, 3-4, 7-9, 11-13, and 15-22 by Yu. The final rejection also failed to establish the obviousness of claims 5-6 and 10 in view of Yu. Accordingly, the rejections of these claims should be reversed and all claims should be passed to issue.

Respectfully submitted,

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APPENDIX A: CLEAN COPY OF CLAIMS INVOLVED IN THE APPEAL

1. (Amended) In a video coder for coding video images in a block format, a method for improving compression of the video images comprising:

predicting x and y motion vector components for a current block of pixels based on a motion vector of at least one neighboring block of pixels to compute x and y components of a predictor motion vector;

computing differential x and y components from the x and y components of the predictor and x and y components of a motion vector for the current block; and

assigning a single variable length code to joint x and y differential motion vector components, wherein the single variable length code is assigned from a variable length code table, the table comprising a list of pairs of joint differential motion vector components and a corresponding variable length code for each pair, such that shorter variable length codes are assigned to joint differential motion vector components that have a higher probability of occurrence in the video images, and longer variable length codes are assigned to joint differential motion vector components that have a lower probability of occurrence, wherein the table includes the most probable pairs of joint differential motion vector components as computed by statistical analysis of example video sequences.

2. (Cancelled)

3. (Amended) The method of claim 1 wherein the assigning includes:

looking up the joint differential motion vector components in the table;

when no match is found in the table, coding an escape code along with a fixed length code for each differential motion vector component.

4. (Twice Amended) The method of claim 1 wherein the block of pixels corresponds to a macroblock in a video frame divided into fixed-sized, rectangular macroblocks, and the predicting, computing, and assigning are repeated for the macroblocks in the video frame.

5. (Twice Amended) The method of claim 1 wherein the block of pixels corresponds to a macroblock of a video object plane in video frame having two more video object planes, and the video object planes are each divided into fixed-sized, rectangular macroblocks; and

the predicting, computing and assigning are repeated for the macroblocks in the video object planes.

6. (Amended) A computer readable medium having instructions for performing the method of claim 1.

7. (Amended) In a video decoder, a method for decoding macroblocks of a predicted video frame comprising:

receiving a single variable length code representing joint x and y components of a motion vector for each of the macroblocks;

for each of the macroblocks, searching for a single entry in an entropy codebook corresponding to the variable length code and including the x and y components of the motion vector, wherein training determines which x and y components to include in the entropy codebook; and

using the x and y components of the motion vector from the codebook to define motion of pixels in a corresponding macroblock.

8. (Unchanged) The method of claim 7 wherein the x and y components of the motion vector in the codebook comprise x and y differential motion vector components, and the method comprises:

reconstructing the motion vector from the differential motion vector components and x and y components of a predictor motion vector.

9. (Unchanged) The method of claim 7 wherein the codebook is a Huffman table trained for a target bit rate and content type from a statistical analysis of example video sequences having the content type.

10. (Amended) A computer readable medium having instructions for performing the method of claim 7.

11. (Amended) A motion vector encoder comprising:

a motion vector predictor for computing a motion vector predictor for a motion vector of a block of pixels from at least one motion vector for a neighboring block of pixels;

a subtractor for computing differential motion vector components from motion vector components of the predictor and the motion vector of the block of pixels; and

a joint entropy coder for jointly coding the differential motion vector components with a single variable length code, wherein statistical analysis indicates which differential motion vector components to represent with variable length codes and which differential motion vector components to represent with an escape code followed by fixed length codes.

12. (Unchanged) The encoder of claim 11 wherein the joint entropy coder computes the single variable length code by searching for the code in a Huffman coding table comprising a list of

joint differential motion vectors and a corresponding variable length code for each of the joint differential motion vectors.

13. (Amended) A motion vector decoder comprising:

a motion vector predictor for computing a motion vector predictor for a motion vector of a block of pixels from at least one motion vector for a neighboring block of pixels;

a joint entropy decoder for decoding a single variable length code into joint differential motion vector components, wherein the joint entropy decoder decodes the single variable length code by searching for the code in a Huffman coding table comprising a list of variable length codes and corresponding joint differential motion vector components for each of the variable length codes, wherein training determines which joint differential motion vector components to include in the table and which joint differential motion vector components to exclude from the table; and

an adder for reconstructing X and Y motion vector components from the joint differential motion vector components and X and Y components of the motion vector predictor.

14. (Cancelled)

15. (Unchanged) The decoder of claim 13 wherein the joint entropy decoder is operable to detect an escape code indicating that two fixed length codes representing X and Y differential motion vector components follow the escape code.

16. (Amended) In a video coder for coding video images in a block format, a method for improving compression of the video images comprising:

computing x and y motion vector components for a block;

forming the x and y motion vector components into a joint parameter representing joint x and y motion vector components; and

assigning a single variable length code to the joint x and y motion vector components, the single variable length code selected from a set of available variable length codes, such that shorter variable length codes are assigned to joint motion vector components that have a higher probability of occurrence in the video images, and longer variable length codes are assigned to joint differential motion vector components that have a lower probability of occurrence, wherein training determines which joint x and y motion vector components to represent in the set of available variable length codes.

17. (Unchanged) The method of claim 16 further including spatially predicting the x and y motion vector components from a neighboring block of the block; and using spatially predicted components as the joint x and y motion vector components.

18. (Unchanged) The method of claim 17 wherein the spatially predicted components are differential motion vector components computed as a difference between x and y components of the motion vector for the block and x and y components of a predictor motion vector.

19. (Amended) In a video decoder, a method for decoding macroblocks of a predicted video frame comprising:

receiving a single variable length code representing joint differential x and y components of a motion vector for each of the macroblocks;

for each of the macroblocks, searching for a single entry in a Huffman table corresponding to the variable length code and including the joint differential x and y components of the motion vector,

wherein the Huffman table includes variable length codes for the most probable joint differential x and y components as computed by statistical analysis of example video sequences;

computing x and y components of a predictor motion vector from neighboring macroblocks to the macroblock currently being decoded; and

reconstructing the motion vector from the differential components obtained from the Huffman table and the x and y components of the predictor motion vector.

20. (Unchanged) In a video coder for coding video images in a block format, a method for variable length coding block motion information of the video images, wherein a joint parameter represents x and y motion vector components for a block, the method comprising:

assigning a single variable length code selected from a set of available variable length codes to the joint x and y motion vector components, wherein training determines which joint x and y motion vector components to represent in the set of available variable length codes.

21. (Unchanged) The method of claim 20 wherein the block is a 16x16 macroblock of pixels, and wherein each of the x and y motion vector components comprises a differential value.

22. (Unchanged) A video decoder including computer-executable instructions for causing a computer programmed thereby to perform a method for variable length decoding macroblock motion information of a predicted video frame, wherein a single variable length code represents joint differential x and y components of a motion vector for each of plural macroblocks, the method comprising:

for each of the plural macroblocks, searching for a single entry in a Huffman table corresponding to the variable length code for the macroblock, wherein the single entry includes the

joint differential x and y components of the motion vector for the macroblock, wherein the joint differential x and y components are combinable with predictor x and y components to reconstruct the motion vector for the macroblock, and wherein the Huffman table includes variable length codes for the most probable joint differential x and y components as computed by statistical analysis of example video sequences.